

1 What is claimed is:

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3 1. A method of vacating a portion of a photoceram, the method
4 comprising,

5 generating a laser beam at a predetermined wavelength within a
6 weak absorption region of the photoceram,

7 focusing the laser beam into a beam waist at a focal depth into
8 the photoceram,

9 illuminating the photoceram by the laser beam to expose a focal
10 volume of the photoceram at a focal depth where the laser beam
11 converts the photoceram into an amorphous exposed material in the
12 focal volume,

13 heating the amorphous exposed material for forming crystallized
14 material from the amorphous exposed material in the focal volume,
15 and

16 dissolving the crystallized material in an acid for evacuating
17 crystallized material from the focal volume and creating a focal
18 volume vacancy defining the portion.

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21 2. The method of claim 1 wherein,

22 the portion serves to suspend another portion of the
23 photoceram.

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26 3. The method of claim 1 wherein,

27 the portion serves to undercut another portion of the
28 photoceram.

1 4. A method of forming a three dimensional embedded structure in a
2 photoceram, the method comprising,
3 generating a laser beam at a predetermined wavelength within a
4 weak absorption region of the photoceram,
5 focusing the laser beam into a beam waist at a focal depth into
6 the photoceram,
7 illuminating the photoceram by the laser beam to expose a focal
8 volume of the photoceram at a focal depth where the laser beam
9 converts the photoceram into an amorphous exposed material in the
10 focal volume,
11 heating the amorphous exposed material for forming crystallized
12 material from the amorphous exposed material in the focal volume,
13 and
14 dissolving the crystallized material in an acid for evacuating
15 crystallized material from the focal volume and creating a focal
16 volume vacancy defining the three dimensional embedded structure.

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19 5. The method of claim 4 wherein,
20 the photoceram is Foturan, and
21 the predetermined wavelength is greater than 350nm.
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26 6. The method of claim 4 wherein,
27 the predetermined wavelength is an ultraviolet wavelength.

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1 7. The method of claim 4 wherein the illuminating step comprises
2 the steps of,

3 exposing the photoceram at the predetermined wavelength for a
4 predetermined number of pulses to provide a critical dose at the
5 focal depth for creating a pixelized volume of amorphous exposed
6 material,

7 moving the photoceram a predetermined step distance relative
8 to the laser beam, and

9 repeating the exposing and moving step a plurality of times
10 for creating a respective plurality of pixelized volumes forming
11 the focal volume.

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13 8. The method of claim 7 wherein,

14 the predetermined number of pulses is between 100 and 10000
15 for delivering the critical dose for converting the photoceram into
16 the amorphous exposed material.

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18 9. The method of claim 4 wherein the dissolving steps 4 further
19 comprising the steps of,

20 forming a top via in the photoceram for communicating the acid
21 into the focal volume for dissolving the crystalline material in
22 the focal volume,

23 dissolving the crystalline material in the focal volume with
24 the acid communicated into the focal volume through the top via,

25 forming a bottom via in the photoceram for vacating dissolved
26 crystalline material out of the focal volume, and

27 vacating the dissolved crystalline material through the bottom
28 via.

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2 10. The method of claim 9 wherein the forming steps for forming
3 the top and bottom via comprise the steps of,
4 exposing the photoceram in a top region for creating a top via
5 volume of amorphous expose material for defining the top via,
6 exposing the photoceram in a bottom region for creating a
7 bottom via volume of amorphous expose material for defining the
8 bottom via, the baking step serving to bake the amorphous exposed
9 material in the top and bottom via volumes into crystallized
10 material, the dissolving step serving to dissolve the crystallized
11 material out of the top and bottom volumes for forming the top via
12 and bottom vias.
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1 11. The method of claim 4 wherein,

2 the illumination step exposes the focal volume during an
3 exposure time at an intensity level,

4 the intensity level and the exposure time provide an exposure
5 dose above a minimum critical dose necessary for converting the
6 photoceram into the amorphous exposed material, and

7 the minimum critical dose is a nonlinear function of the
8 intensity level.

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12 12. The method of claim 4 wherein,

13 the laser is a pulsed laser,

14 the laser beam is a pulsed laser beam having a predetermined
15 number of pulses,

16 the illumination step exposes the focal volume for the
17 predetermined number of pulses having a per pulse fluence level
18 over a predetermined pulse width time,

19 the per pulse fluence level and the predetermined number of
20 pulses provide an exposure dose above a minimum critical dose
21 necessary for converting the photoceram into the amorphous exposed
22 material, and

23 the minimum critical dose is a nonlinear function of the per
24 pulse fluence level.

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1 13. A method of forming a three dimensional embedded structure in a
2 photoceram, the method comprising,
3 generating a pulsed laser beam at a UV wavelength within a weak
4 absorption band of the photoceram,
5 focusing the laser beam into a beam waist at a focal depth into
6 the photoceram,
7 exposing the photoceram at the UV wavelength a predetermined
8 number of pulses at focal depth for creating a pixelized volume of
9 amorphous exposed material,
10 moving the photoceram a predetermined step distance, and
11 repeating the exposing and moving step a plurality of times
12 for creating a respective plurality of pixelized volume forming a
13 focal volume,
14 heating the photoceram to heat the amorphous exposed material
15 in the focal volume to bake the amorphous material into a
16 crystallized material, and
17 dissolving the crystallized material in an acid for evacuating
18 the crystallized material from the focal volume creating a focal
19 volume vacancy defining the three dimensional embedded structure.

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21 14. The method of claim 13 wherein,
22 the photoceram is Foturan,
23 the ultraviolet wavelength is 355nm, and
24 the number of pulses is between 100 and 10000.

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26 15. The method of claim 13 wherein,
27 all the steps are repeated for forming a plurality of
28 embedded structures.

1 16. The method of claim 13 wherein the embedded structure is an
2 undercut structure.

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4 17. The method of claim 13 further comprising the step of,
5 agitating the acid for transporting the acid through the top
6 via into the focal volume.

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8 18. The method of claim 13 further comprising the step of,
9 pressurizing the acid for transporting the acid through the
10 top via into the focal volume.

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12 19. The method of claim 13 wherein the illumination laser beam has
13 a Gaussian profile and is focused at the focal depth in the
14 photoceram.

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17 20. The method of claim 13 wherein,
18 the UV wavelength is at an edge between the weak absorption
19 region and the strong absorption region of the photoceram,
20 the illumination step exposes the focal volume for the
21 predetermined number of pulses having a per pulse fluence level
22 over a predetermined pulse width time,
23 the per pulse fluence level and the predetermined number of
24 pulses provide an exposure dose above a minimum critical dose
25 necessary for converting the photoceram into the amorphous exposed
26 material, and
27 the minimum critical dose is a nonlinear function of the per
28 pulse fluence level.